

Pectoralis Major Injuries in the Army, CY 2016 Active Duty Army

PHIP No. 12-03-0719

Approved for public release; distribution unlimited

General Medical: 500A

July 2019



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PUBLIC HEALTH INFORMATION PAPER NO. 12-01-0218
PECTORALIS MAJOR INJURIES IN THE ARMY,
CY2016 ACTIVE DUTY ARMY

1 PURPOSE

The purpose of this analysis is to estimate the incidence and costs of pectoralis major injury encounters among Active Duty Army Soldiers in calendar year (CY) 2016.

2 REFERENCES

References cited are listed in Appendix A.

3 INTRODUCTION

3.1 Musculoskeletal injuries

Musculoskeletal (MSK) injuries are the leading cause of medical visits among Active Duty soldiers and a leading cause for physical duty restrictions and non-deployment.^[1-3] Muscle and tendon strains and tissue damage caused by overuse are especially common types of MSK injury. These include injuries to the pectoralis major.

3.2 Types of Pectoralis Major Injuries

The pectoralis major is the thick, fan-shaped muscle (PMM) that stretches from collarbone (clavicle) and the breastbone (upper sternum) across the chest attaching to the upper arm bone (humerus) as a tendon (PMT) (Figure 1).^[4-7] The upper portion of the muscle is described as the clavicular head and the lower portion the sternal head. Most recognized PMM/PMT injuries occur after acute trauma. While relatively rare, the most severe form is referred to as a ruptured or torn “pec.” Acute traumatic ruptures occur at one of four locations^[4,5,7-11] —

- (1) the insertion of the clavicular head of the PMT at the humerus (most frequent injury location),
- (2) the junction of the PMM and PMT (musculotendinous),
- (3) within the muscle belly itself, or
- (4) the origin of the PMM at the clavicle or sternum.

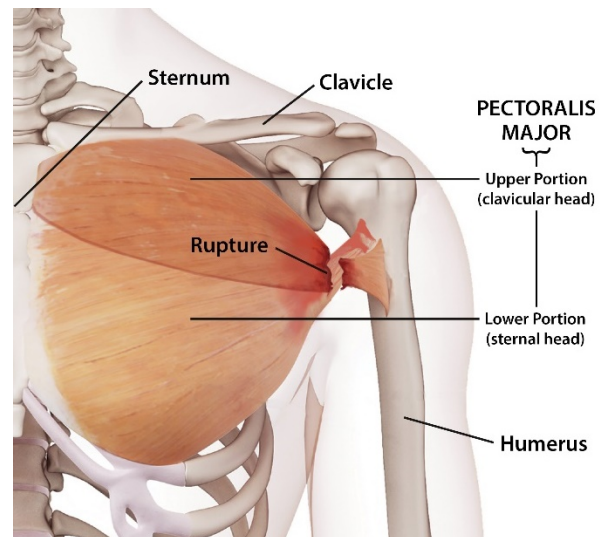


Figure 1. Location of Pectoralis Major

The most common mechanism of an acute PMM/PMT injury is a sudden excessive force on one side of the body during an eccentric contraction of the muscle when the arm is extended and rotated outward.^[1,6,7] Injuries from this mechanism most frequently occur during the bench press, an upper-body weight training exercise in which a person presses a weight (usually a

weighted barbell) upwards while lying on a bench.^[4-9,12-17] As individuals are lowering the weighted bar to their chest, muscle fatigue or weakness can abruptly interrupt muscle control.^[10,11,13-15] Though much less common, the mechanism and resulting PMM/PMT injury may also happen during an accidental fall, other strength-training activities (e.g., weighted-dip, dumbbell fly, push-ups), or other sport and recreational physical activities (e.g., martial arts, wrestling, rugby, skiing, gymnastics, and parachuting).^[7-9,18]

Complete PMM/PMT ruptures or tears are often associated with a sudden, audible snap in the chest or shoulder. The PMM may retract and create a visible lump or deformity in the front chest or shoulder region. There is often rapid swelling and/or muscle weakness in the front of the shoulder and upper arm. Pain is usually immediate but may be delayed, and substantial bruising will often develop in the chest and upper arm. Tests which reproduce pain (such as having the patient pull their arm across the front of the chest or rotate it inwards against resistance) can help confirm the diagnosis.^[5,7,10-12] Current evidence suggests that early diagnosis and surgical interventions of complete PMM/PMT ruptures and tears lead to the most optimal long-term outcomes.^[4-7,9,11,13] Time to full return-to-work cited in the literature range from 3 to 12 months (mean durations cited were 4 to 8.5 months).^[6,9,12,19] Despite returning to work, objective strength may be permanently reduced following injury (25 to 40%)^[9,14] and heavy weight-training performance is typically discouraged to avoid re-injury.^[4,9,19]

Though PMM/PMT injuries are most frequently recognized when they are acute traumatic ruptures requiring surgery, they also include acute partial tears (sprains) as well as cumulative traumatic injuries (overuse injuries).^[14,17,20] Overuse injuries result from the accumulation of micro-traumatic tears caused by excessive frequency, duration, too much weight, and/or repeated use. Though signs and symptoms may be less severe and treatment would not require hospitalization, these milder PMM/PMT sprains and overuse injuries will often result in pain, inflammation, and/or muscle weakness. These less severe injuries are presumed to be medically diagnosed as either sprains or more generally as muscle pain in the upper arm and chest region. They still require medical evaluation, treatment (e.g., physical therapy, medication) through outpatient services. Symptoms are more noticeable when the muscle is activated; therefore, physical restrictions are often imposed to allow the tissues to heal. Estimates for lost or restricted duty time to Army soldiers attributed to upper body sprains range from 30 to 120 days.^[21,22] Long-term impacts to strength and performance are not described, but evidence suggests that injured tissues are more prone to re-injury.^[9,19]

While relatively rare MSK injuries, the incidence of severe acute PMM/PMT ruptures has reportedly been increasing in the last two decades.^[4,5,17] This phenomenon, also noted in military populations, has been attributed to the growing popularity in weight training.^[9,14-17] The evidence of association between this unique upper-body injury and a specific weight-training activity (bench press) provided the basis for this investigation.

3.3 Study Objectives

The literature has focused on PMM/PMT ruptures requiring surgical hospitalization.^[9,12] It is hypothesized that less severe PMM/PMT sprains and overuse injuries are even more common. This investigation was to estimate the incidence and resulting lost duty time and cost of acute and overuse PMM/PMT injuries among Army Soldiers. The findings and the unique association with the bench press will support future surveillance and MSK injury prevention initiatives.

4 METHODS

This investigation applied the Army's injury surveillance protocol for identifying injuries using selected International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) medical diagnostic codes documented in Soldiers' medical records.^[23,24]

4.1 Study Population

The study population included Service members on Active status in the Army during CY2016. This investigation used the reported size of the Active Duty Army population in October 2016 as 473,028, of which 15% (69,592) are women (Appendix B).^[25]

4.2 Study Design

This analysis was a retrospective analysis of CY2016 Active Duty Soldiers' medical records in the Military Health System Data Repository (MDR) to estimate the incidence and cost of PMM/PMT injury-related medical encounters (for both for newly diagnosed cases and those for ongoing care).

4.3 PMM/PMT Injury Codes

Because there is not a single ICD-10-CM diagnostic code for pectoralis major ruptures/tears (strains), initial codes considered to plausibly include pectoralis major injuries were selected a priori.^[23,25] Initial codes used to identify potential PMM/PMT encounters in MDR included: S29.011* (Strain of muscle and tendon of front wall of thorax), S43.4* (Dislocation and sprain joints and ligaments of shoulder girdle), and S46.91* (Strain of unspecified muscle, fascia and tendon at shoulder and upper arm level).

The probabilities that these codes were used to diagnose pectoralis major injuries were systematically estimated by a clinical provider using the Armed Forces Health Longitudinal Technology Application. To refine and validate the use of selected codes, the provider reviewed 100% of the identified Soldiers' hospitalization records and a 10% random selection of outpatient records for each initially selected code. To estimate the probability that a diagnosis would be used to describe a PMM/PMT injury, the provider identified case descriptions that definitively specified the pectoralis major or contained a medical description plausibly suggesting this injury. The proportion of reviewed encounters that identified the pectoralis major was estimated to be the probability. Records that specified or implied other forms of injury or other injured tissues (e.g., rotator cuff or acromioclavicular joint) were excluded.

Using the probabilities (percentages) of pectoralis major injuries in the reviewed records, weight factors (WFs) were applied to the initial codes to estimate pectoralis major incidence. All encounters coded with S43.4 were excluded (WF=0) due to only two of 109 reviewed records specifying pectoralis major injuries. For S29.011, 100% of the CY 2016 Active Duty hospitalizations were confirmed to be pectoralis major ruptures (hospitalization WF=1.0). For outpatient records with this code, 22 (60%) of the 10% random selection (36/372 Soldiers) were specified as pectoralis major injuries. Therefore, a WF=0.60 was applied to outpatient encounters with S29.011* as a primary diagnosis. For S46.91*, the probability of hospitalization

was 100% and for outpatient was % 5 (10/109 reviewed Soldiers). Applied WFs to the S46.91* encounters were 1.0 for hospitalizations and 0.05 for outpatient encounters.

Based on the clinical review of cases definitively specified as PMM/PMT injuries, the clinical reviewer also recorded ten additional 6-digit S-codes and two M-codes that were documented in the medical records. Though several codes were considered to be to infrequently noted, one additional S-code (S46.81*, Strain of other muscles, fascia and tendons at shoulder, and upper arm level) and one M-code (M25.51, pain in shoulder) were added. Encounters for these codes was obtained, and the WF determined for S46.91* (WF=0.05) was applied to estimate outpatient pectoralis major injury probabilities.

4.4 Data Sources

4.4.1 Medical Encounters

Medical records for Active Duty Army Service Members that included the selected ICD-10-CM injury encounter codes in CY2016 were obtained from the following MDR files using the Military Health System Mart (M2) interface—

- For hospitalization—
 - Standard Inpatient Data Record (SIDR), for military treatment facility (MTF) inpatient encounter data.
 - TRICARE¹ Encounter Data Institutional (TED-I), network inpatient encounter data.
- For outpatient data—
 - Comprehensive Ambulatory/Professional Encounter Record (CAPER), for MTF outpatient encounter data.
 - TRICARE Encounter Data Non-Institutional (TED-NI), for out of network outpatient encounter data.

Encounters for the study population were identified in the M2 files using the beneficiary category (BenCAT) variables for Active Duty (ACT) as defined in the M2 data dictionary. The Service component variable was designated for Army (A) Service members. Only the ICD-10-CM codes located in primary diagnosis code position (DX1) were included. Table 1 provides additional details about the data extraction for each ICD-10-CM code of interest.

Table 1. Population and Injury Data Extracted from Different Sources

Source	Specifications/variables
CAPER	CY=16; Service component= A; BenCAT = ACT; Age; Gender; Marital status; DX1-8; PROC1-2; Full Cost; Injury related; Injury place; Injury related cause code; Encounter date

¹ TRICARE is a healthcare program of the U.S. Department of Defense Military Health System. Tricare provides Civilian health benefits for military personnel, military Retirees, and their dependents, including some members of the Reserve Component.

Source	Specifications/variables
SIDR	CY=16; Service component= A; BenCAT = ACT; Age; Gender; Marital status; DX1-9; PROC1-2; Full Cost; Injury Code, STANAG; Injury Location; Injury Date; Admission Date; Discharge Date; Length of Stay
TED-NI	CY=16; Service component= A; BenCAT = ACT; Age; Gender; DX1-4; Procedure Code; Procedure Description; Amount Paid; Begin Date
TED –I	CY=16; Service component= A; BenCAT; Age; Gender; DX1-8; PROC1-2; Amount paid; Admission Date; End Date; Discharge status. NOTE: No Service members found

Notes:

BenCAT= beneficiary category; ACT=Active Duty; per the M2 data dictionary.

Data last pulled 03/8/19; variable “race” extracted but not included because most data fields were blank.

4.4.2 Costs

The direct medical costs associated with each of the encounters presumed to be PMM/PMT injuries were obtained from M2. For MTF inpatient visits, total direct cost includes all ancillary costs (e.g., lab and radiology), salaries (e.g., clinicians), and direct-unit costs based on medical expense and performance-reporting expenses (adjusted for inflation) associated with inpatient care. For outpatient encounters, total direct cost is based on allocation of Medical Expense and Performance Reporting System dollars by Relative Value Units and Ambulatory Payment Classifications. For care provided in network facilities (both inpatient and outpatient), the total cost includes the total amount paid by TRICARE.

Indirect costs associated with lost duty days were based on DoD Military and Personnel Composite Standard Pay and Reimbursement Rates guidance for CY2016, using the daily cost to the Army (\$333/day) for the loss of work of a Soldier at a rank of E4, with in-Service time of 8 years in 2016 (\$75,897 multiplied by 0.00439=\$333).^[23]

4.5 Analyses

Analyses for this investigation included estimations for—

- The number of PPM/PMT medical encounters (both hospitalizations and outpatient encounters) by type of care, total number of Soldiers, and average number of encounters per Soldier were estimated based on encounters identified with ICD-10-CM codes among the CY2016 study Active Duty Army population and applying assigned WFs. Data are displayed overall and stratified by gender.
- Direct medical costs for this investigation were the costs of medical resources within the healthcare delivery system based on total paid costs reported by type of care (hospitalization, outpatient encounter). Average costs were calculated per encounter and per Soldier.
- Indirect costs for this investigation were estimated as lost time to conduct normal assigned physical duties based on estimated restricted duty times and pay averages. A conservative (low-end) estimate was calculated using the following assumptions: (1) \$333 as a conservative daily rate for the loss of work of a Soldier^[26] and (2) a low-end

lost or restricted duty-day duration of 6 months for hospitalizations (120 days) and 2 months (60 days) for outpatient encounters.^[9,19,21,22]

5 RESULTS

Table 2 depicts the results of the overall estimated CY2016 Active Duty PMM/PMT injuries based on the selected ICD-10-CM codes with associated WFs. Using the selected codes, 14 hospitalizations and 245,858 outpatient encounters were identified. Based on the clinical review and derived WFs, five hospitalizations (38%) were confirmed to be PMM/PMT injuries. An estimated 12,672 outpatient encounters (5%) were determined to be PMM/PMT injuries.

Table 3 presents the estimated number of total and average encounters for all hospitalization and outpatient encounters, percentage by gender, and associated direct costs. Data indicate that five Active Duty male Soldiers were hospitalized, and 2,763 Active Duty Soldiers (87% men; 13% women) had outpatient encounters for a PMM/PMT injury in CY2016. Soldiers averaged five encounters for each injury event. Four of the five hospitalized Soldiers were under 24 years of age. The largest percentage of injured soldiers (36% of all identified Soldiers) were 25 to 34 years of age, and the least injured were those 45 years and older (data not shown).

The estimated average direct medical cost of a PMM/PMT outpatient encounter (\$143) was approximately 1% of the average cost for a hospitalization (\$14,192). The total direct cost of hospitalizations in CY2016 (\$70,962) was less than 4% of the estimated direct cost of outpatient encounters (\$1,818,144).

The total estimated lost or restricted duty days for the identified PMM/PMT injuries was calculated to be 166,380 days (i.e., 120 days/Soldier (for hospitalization) x 5 Soldiers = 600 days, plus 60 days/Soldier (for outpatient) x 2,763 Soldiers = 165,780 days). This resulted in a low-end indirect cost estimate of \$55,404,540 (120 lost/restricted duty days (for hospitalization) x \$333/day x 5 Soldiers (\$199,800), plus 60 lost/restricted duty days (for outpatient) x \$333/day x 2,763 Soldiers = \$55,204,740). Total estimated cost (direct and indirect) was, therefore, \$57 million.

Table 2. Diagnosis Codes and Estimated Frequency of Pectoralis Major Injury Encounters, Active Duty Soldiers, CY2016

ICD-10-CM Diagnosis Codes and descriptions			Hospitalizations, N	WF†	Estimated PMM/PMT Hospitalizations, n	Outpatient encounters, N	WF†	Estimated PMM/PMT Outpatient encounters, n
S29	S29.009*	Unspecified injury of muscle and tendon of unspecified wall of thorax	0	0.0	0	11	0.00	0
	S29.011*	Strain of muscle and tendon of front wall of thorax	4	1.0	4	690	0.60	412
	S29.019*	Strain of muscle and tendon of unspecified wall of thorax	0	0.00	0	247	0.05	12
	S29.021*	Laceration of muscle and tendon of front wall of thorax	0	0.00	0	51	0.00	0
	S29.029*	Laceration of muscle and tendon of unspecified wall of thorax	0	0.00	0	0	0.00	0
	S29.091*	Other injury of muscle and tendon of front wall of thorax	0	0.00	0	1	0.00	0
	S29.099*	Other injury of muscle and tendon of unspecified wall of thorax	0	0.00	0	1	0.00	0
S46	S46.80*	Unspecified injury of other muscles, fascia and tendons at shoulder and upper arm level	1	0.00	0	18	0.00	0
	S46.81 *	Strain of other muscles, fascia and tendons at shoulder and upper arm level	2	0.00	0	2,857	0.05	143
	S46.82	Laceration of other muscles, fascia and tendons at shoulder and upper arm level	1	0.00	0	4	0.00	0
	S46.90*	Unspecified injury of unspecified muscle, fascia and tendon at shoulder and upper arm level	0	0.00	0	58	0.00	0
	S46.91*	Strain of unspecified muscle, fascia and tendon at shoulder and upper arm level	1	1.00	1	2,826	0.05	141
	S46.92*	Laceration of unspecified muscle, fascia and tendon at shoulder and upper arm level	0	0.00	0	14	0.00	0
M-codes	M25.51*	Pain in shoulder	6	0.00	0	239,238	0.05	11,962
	M62.11*	Other rupture of muscle (nontraumatic) [shoulder]	0	0.00	0	8	0.00	0
Totals			14		5	245,858		12,672

NOTES:

† weight-factor = reflects probability, determined by clinical review, that code was used to diagnose a pectoralis major injury * extension used in search.

- S29.8* Other specified injuries of thorax and S29.9* Unspecified injury of thorax, due to lack of specificity/generic diagnosis description.
- S43.4 Dislocation and sprain, based on clinical review (109/ 2039 records reviewed, 2 PMM/PMT); also S23 Dislocation and sprain of joints/ligaments of thorax.
- Following codes (though during clinical review if records a few cases used these codes (<5 each) for diagnosis of PMM/PMT injuries:
M63 Disorders of muscle in diseases not classified elsewhere (nec) [shoulder/upper arm]; M95 Other acquired deformities of musculoskeletal system and connective tissue.
M96 Intraoperative and post-procedural complications and disorders of musculoskeletal system, nec; M99 Biomechanical lesions, nec: [thoracic region, upper extremity rib cage]

Table 3. Estimated Pectoralis Major Muscle/Tendon Injury Encounters Among Active Duty Soldiers, CY2016

Medical Encounters		Soldiers				Direct Costs		
Location of Care	Total #	Total #	Average # Encounters per Soldier	%Men	%Women	Total Direct Cost	Average Cost per Encounter	Average Cost per Soldier
Hospitalizations	5	5	1	100%	0%	\$70,962	\$14,192	\$14,192
Outpatient	12,672	2,763	5	87%	13%	\$1,818,144	\$143	\$658

NOTE:

Soldiers treated as Inpatient also sought Outpatient services.

6 DISCUSSION

6.1 General

The finding of five hospitalized cases of pectoralis major ruptures in the Active Duty Army in CY 2016 shows that these severe MSK injuries are still relatively rare among soldiers.^[9,16] However, this study indicates that milder forms of PMM/PMT strains and overuse injuries treated through outpatient are more costly to the Army in dollars and restricted or lost duty. The literature indicates PMM/PMT injuries have been increasing in recent decades due to the growing popularity of weight-training, specifically the bench press.^[4-6,14,15] The bench press is a particularly common weight-training lift but does not mimic performance or function of military job tasks. Though Soldiers are not required to perform the bench press, they are increasingly being encouraged to enhance upper body strength when training for their physical fitness test.^[27] In addition, most military and Army physical fitness training facilities (even in austere deployment settings) provide weight-training equipment, including the bench press, for Soldier's personal use. As a result of these factors, and with the wide availability of military-provided equipment, Soldiers are expected to perform the bench press more frequently, thus, increasing their risk of PMM/PMT injuries.

6.2 Upper Body Injuries in the Army

The PMM/PMT injuries identified in this investigation are normally captured along with other upper body or upper extremity MSK injuries in routine military injury surveillance.^[1,3, 22,25] The Army has focused its attention on injuries to the lower extremities, which is the primary body region injured during military activities such as distance running and foot marching.^[19,21,25,26] However, 34% of the 556,580 soldiers with lower and upper body injuries in CY 2016 had upper body injuries (Table 4).^[30] Clearly, upper body injuries are not inconsequential.^[2] The causes of these injuries need to be identified so the Army can design targeted and actionable prevention strategies. Towards this goal, this investigation has identified a type of injury (pectoralis major injury) with a relatively exclusive and potentially preventable cause (bench press).

Evidence indicates that the shoulder is the body region most commonly injured during weight-training.^[14,15,20] While this investigation focused only on the identification of acute and overuse PMM/PMT injuries, it is reasonable to assume that many other Soldiers' shoulder-related MSK injuries can be attributed to the bench press. Common weight-training injuries include the PMM/PMT injuries investigated in this study as well as injuries to the rotator cuff and the acromioclavicular joint, including stress fractures to the subchondral bone at the distal clavicle.^[31,32] Localized pain in the shoulder, due to acromioclavicular joint damage, is frequently described as "weight-lifters shoulder" and is commonly attributed to bench press exercises.^[14,15,20] Shoulder injuries have been attributed to other exercises such as the weighted dip and dumbbell fly, deadlifts, bicep curls, and even push-ups.^[20] It is important to consider these other weight-training injuries and causal exercises when developing prevention strategies and alternative exercise recommendations.

Table 4. Army Injuries to Lower Extremities versus Upper Extremities, CY 2016

General Body Region	Month	Soldiers with Injuries	Soldiers with >1 Encounter	
			#	%

Lower Extremity	January	28,895	10,299	36
	February	29,880	11,047	37
	March	33,801	13,202	39
	April	32,104	12,275	38
	May	30,324	11,313	37
	June	30,634	11,939	39
	July	27,892	10,836	39
	August	33,173	13,443	41
	September	32,549	12,557	39
	October	32,595	12,732	39
	November	30,666	11,700	38
	December	25,433	9,354	37
	TOTAL CY2016	367,946	140,697	38
Upper Extremity	January	15,015	5,777	38
	February	15,831	6,284	40
	March	17,403	7,049	41
	April	16,344	6,664	41
	May	15,582	6,150	39
	June	15,460	6,059	39
	July	14,425	5,522	38
	August	16,815	6,971	41
	September	16,136	6,519	40
	October	16,524	6,847	41
	November	15,533	6,113	39
	December	13,566	5,232	39
	TOTAL CY2016	188,634	75,187	40

Source: Armed Forces Health Surveillance Branch, Installation Reports, January 2016–January 2017^[27]

6.3 PMM/PMT Injury Impact to the Army

This investigation found that, out of 473,028 Army Active Duty Soldiers in CY2016, five Soldiers were hospitalized for a PMM/PMT injury. This finding is consistent with the literature's characterization of PMM/PMT ruptures as a relatively rare acute traumatic injury.^[5,9-11,13,16] These five hospitalizations were confirmed to be PMM/PMT cases through a clinical review of the records. Four were diagnosed as "Strain of muscle and tendon of front wall of thorax" (S29.011), and the other one was diagnosed as "Strain of other muscles, fascia and tendons at shoulder and upper arm level" (S46.81). The estimated lost or restricted duty time of CY2016 PMM/PMT injuries was estimated as 120 days each, totaling 600 days, which is the equivalent of over 2 man-years.

In addition, this investigation estimated the occurrence of outpatient PMM/PMT injuries among Active Duty Soldiers that have not been previously described in the literature. The findings indicate that an estimated 2,763 Soldiers (approximately 0.1% of the CY2016 Active Duty Army) were treated as an outpatient for a PMM/PMT injury. These outpatient encounters were diagnosed using medical codes that described strains to muscles, fascia, and tendons upper arm and shoulder region and pain in the shoulder region. These injured Soldiers typically had five visits for their injury. It is reasonable to assume that the majority of these injuries involved some temporary physical limitations. The literature supports a low-end estimate of 60 days for

the lost or restricted duty time attributed to reduced physical performance for an upper body strain such as that of the PMM/PMT.^[21,22]

The Army's direct medical cost of CY2016 PMM/PMT encounters was \$2 million. Over 97% of this direct cost is due to the outpatient encounters, despite the average outpatient encounter costing less than 1% of a hospitalized PMM/PMT injury. Even more substantial are the indirect costs of reduced physical work performance due to restricted or lost duty days. This investigation estimated over 165,800 lost or restricted duty days for the CY2016 PMM/PMT injuries, at a cost of approximately \$55 million. This is considered a conservative estimate because it: (1) is based on a low-end estimate of physical performance time loss, (2) does not account for other sources of indirect costs, and (3) does not account for the longer term or even permanent work restrictions (i.e., a reduction of 25% to 50% in objective measures of strength)^[16,19] to some personnel that would require a change to their original work-duty tasks or military occupational skill assignment.

6.4 Army Soldiers and Risk Factors

This investigation found that all five of the PMM/PMT hospitalizations in CY2016 and the majority of outpatient encounters (87%) were for male Soldiers. The ages of hospitalized patients ranged from 20 to 25 years of age. The ages of patients requiring only outpatient care ranged from 25 to 44. This is consistent with the literature indicating that PMM/PMT injuries primarily occur among men ranging between 20 and 40 years of age.^[5,7]

Of the five hospitalizations, all were noted to have been caused by the bench press. Outpatient medical records do not require documentation of a cause, though the clinical reviewer identified some cases indicating that the patient had been bench pressing heavy weights when injured. The literature characterizes bench pressing heavy weights (ranging from 185 to 365 pounds, average 270 pounds) as a primary risk factor for PMM/PMT injury.^[4,6,9,12,14] While more rare, PMM/PMT injuries caused by muscle fatigue while lowering an individual's body weight during push-ups has been documented in the literature.^[17] Two medical records reviewed in this investigation indicated the push-up as the causal activity.

Risk factors for PMM/PMT injuries in the Army population are also supported by White et al.,^[10] where an evaluation of muscle tendon (including PMT) ruptures within the U.S. Active-Duty Army population, found that gender (male), age (20 to 40), and specific training activity (bench press) were key factors associated with injury. White et al. also found race to be a predisposing risk factor, with a risk ratio of black men to white men of 13.7(95% confidence level (CI), 3.8-45.4)). Another possible risk factor is the use of anabolic steroids, which is linked with chronic tendinopathy—a condition that may increase tendon susceptibility to tissue damage from extreme mechanical force.^[4,14,15] However, due to the serious disciplinary repercussions for anabolic steroid use in the Army population, this factor may be less likely.^[9]

Four of the five hospitalized PMM/PMT injuries occurred at West Point. This is consistent with literature that suggests competitive weight training environments (e.g., in Army school houses, powerlifting or bodybuilding competitions), and/or austere military environments (e.g., deployment settings) may be a risk factor for PMM/PMT injuries.^[9,15,17] The small portion of the clinical records reviewed suggest certain Army locations that may have physically competitive training environments (e.g., Ft. Bragg, Ft. Rucker) and/or austere environmental conditions (e.g., deployment locations, Ft. Drum).

6.5 Study Benefits and Limitations

Prior studies of PMM/PMT injuries have relied on clinical reviews of medical records from primarily severe cases of complete PMM/PMT ruptures or tears.^[4-8,12,16,17] These studies suggest an increasing prevalence of PMM/PMT injuries within the last 2 decades but primarily focus on treatment and outcomes for complete PMM/PMT ruptures or tears requiring surgical intervention. No studies addressing prevention of these injuries were found during this investigation. In addition, none of the studies identified characterized milder strains and overuse PMM/PMT injuries that are treated through outpatient services. Identifying these additional forms of PMM/PMT injuries is more problematic since ICD-10-CM code(s) used to diagnose PMM/PMT injuries can be varied and can be used to diagnose other types of injuries within the same body region. However, for epidemiological surveillance purposes, inclusion of only hospitalized cases is too limiting to adequately characterize the full impact of these injuries. Therefore, the ICD-10-CM diagnoses codes in conjunction with WFs served as a reasonable conservative approach to estimate the full range of PMM/PMT injuries (including ruptures, partial tears, mild sprains, and overuse) among Soldiers.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Upper body injuries, particularly those of the shoulder, and their causes have been under-recognized in Army injury surveillance. Many of these injuries, including PMM/PMT, acromioclavicular joint, and rotator cuff injuries, may be attributed to weight training, specifically the bench press. This study has only evaluated PMM/PMT injuries as a surrogate for what is plausibly a larger injury problem. Though the most recognized type of PMM/PMT injury is a severe rupture requiring surgical repair, less severe outpatient PMM/PMT strains and overuse injuries are more common and present a more notable burden to the Army.

Prevention of these injuries should be considered a priority since these injuries—

- are increasing in the military,
- involve costly treatments,
- can result in long periods of physical restrictions and or lost-work capabilities (3 months to a full year), and
- can result in permanent loss of strength (with possible reassignment of work duties).

The literature supports an almost exclusive causal association between PMT/PMT injuries and the bench press. This activity is specific, not a doctrinally required military training activity (such as running and foot marching) and does not mimic performance of a job task. Since the bench press is not necessary to improve one's performance of any functional task, a primary intervention is avoidance of this exercise. Further assessment of alternative exercises to the bench press (e.g., cable crossover fly, dumbbell press, pec deck fly, or dumbbell pullover) is recommended. Facilities that provide bench-press equipment should ensure posting of general technique guidance and injury warnings. Educating weight trainers on proper technique guidance and increasing awareness of PMM/PMT injuries and possible risk factors (e.g., excessive weight, and repetitions for an individual's training level, or anabolic steroid use) may also minimize future occurrence of these injuries.

7.2 Recommendations

This investigation supports the following public health actions:

- Develop injury prevention products to increase awareness of PMM/PMT injuries and to provide general bench-press technique guidance and alternative weight-training activities.
- Implement prevention initiatives for PMM/PMT injuries at Army facilities that provide Soldiers the equipment to conduct the bench press. Prioritize facilities with physically competitive training environments such as school houses, basic and advanced training centers, and locations with austere outdoor environmental conditions (e.g., deployment settings, extreme hot or cold weather locations).
- Monitor rates of shoulder and upper extremity injuries at installations with large numbers of Soldiers using weight-training facilities, and compare differences between locations that have instituted prevention initiatives identified above.
- Evaluate future trends in PMM/PMT injuries using the case definition developed in this investigation (i.e., the specific ICD-10-CM codes and WFs shown in Table 2) to ensure comparability.

8 POINT OF CONTACT

The APHC Injury Prevention Division is the point of contact for this project and can be reached via email at usarmy.apg.medcom-aphc.mbx.injuryprevention@mail.mil; or by phone at 410-436-4655 (commercial) or 584-4655 (DSN).

APPENDIX A

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APPENDIX B

Distribution of Active Duty Military Personnel by Rank/Grade

Table B-1. Active Duty Personnel, October 2016

Department of Defense					
Active Duty Military Personnel by Rank/Grade					
October 31, 2016					
Rank/Grade	Services				Total Services
	Army	Navy	Marine Corps	Air Force	
GENERAL -ADMIRAL	11	10	4	13	38
LT GENERAL -VICE ADMIRAL	45	39	16	40	140
MAJ GENERAL -REAR ADMIRAL(U)	126	61	29	85	301
BRIG GENERAL -REAR ADMIRAL(L)	129	100	37	147	413
COLONEL -CAPTAIN	4,172	3,142	641	3,293	11,248
LIEUTENANT COL-COMMANDER	8,978	6,553	1,894	9,543	26,968
MAJOR -LT COMMANDER	15,273	10,504	3,852	12,899	42,528
CAPTAIN -LIEUTENANT	28,963	18,513	5,933	21,031	74,440
1st LIEUTENANT-LIEUTENANT(JG)	10,739	6,722	3,501	7,032	27,994
2nd LIEUTENANT-ENSIGN	8,587	6,968	2,792	6,637	24,984
CHIEF WARRANT OFFICER W-5	580	73	103	0	756
CHIEF WARRANT OFFICER W-4	1,928	374	288	0	2,590
CHIEF WARRANT OFFICER W-3	4,142	584	592	0	5,318
CHIEF WARRANT OFFICER W-2	5,856	636	874	0	7,366
WARRANT OFFICER W-1	2,039	0	181	0	2,220
TOTAL OFFICER	91,568	54,279	20,737	60,720	227,304
E-9	3,303	2,550	1,550	2,503	9,906
E-8	10,574	6,423	3,812	4,990	25,799
E-7	34,807	21,349	8,322	24,489	88,967
E-6	54,045	46,677	14,830	39,650	155,202
E-5	64,702	63,669	26,110	59,079	213,560
E-4	114,267	52,748	35,217	59,438	261,670
E-3	47,047	49,966	42,967	44,113	184,093
E-2	25,577	13,676	19,211	6,901	65,365
E-1	22,655	8,012	11,080	10,666	52,413
TOTAL ENLISTED	376,977	265,070	163,099	251,829	1,056,975
CADETS-MIDSHIPMEN	4,483	4,421	0	4,152	13,056
GRAND TOTAL	473,028	323,770	183,836	316,701	1,297,335

Source: Defense Manpower Data Center (DMDC), https://www.dmdc.osd.mil/appj/dwp/dwp_reports.jsp

Table B-2. Active Duty Female Personnel, October 2016

Table of Active Duty Females by Rank/Grade and Service as of: October 2016							
Data Source: DMDC, Active Duty Master Personnel File, Military Academies							
Rank/Grade	Army	Navy	Marine Corps	Air Force	TOTAL	DoD Total	Pct Females
O10	0	1	0	2	3	38	7.9%
O09	4	4	0	5	13	140	9.3%
O08	6	5	1	8	20	301	6.6%
O07	8	13	0	7	28	413	6.8%
O06	470	384	17	454	1,325	11,248	11.8%
O05	1,230	779	76	1,477	3,562	26,968	13.2%
O04	2,849	1,679	228	2,525	7,281	42,528	17.1%
O03	5,798	3,809	425	4,750	14,782	74,440	19.9%
O02	2,121	1,453	382	1,743	5,699	27,994	20.4%
O01	1,779	1,532	276	1,555	5,142	24,984	20.6%
W05	39	6	4	0	49	756	6.5%
W04	156	15	15	0	186	2,590	7.2%
W03	398	37	31	0	466	5,318	8.8%
W02	565	55	61	0	681	7,366	9.2%
W01	214	0	11	0	225	2,220	10.1%
Officer Total	15,637	9,772	1,527	12,526	39,462	227,304	17.36%
E09	279	168	53	366	866	9,906	8.7%
E08	1,190	571	185	1,024	2,970	25,799	11.5%
E07	4,129	2,576	493	4,956	12,154	88,967	13.7%
E06	5,862	6,294	997	7,519	20,672	155,202	13.3%
E05	9,314	11,559	2,355	10,916	34,144	213,560	16.0%
E04	17,383	11,240	3,130	10,679	42,432	261,670	16.2%
E03	7,565	12,139	3,387	9,029	32,120	184,093	17.4%
E02	4,026	3,467	1,988	1,399	10,880	65,365	16.6%
E01	3,301	2,023	837	2,180	8,341	52,413	15.9%
Enlisted Total	53,049	50,037	13,425	48,068	164,579	1,056,975	15.57%
Total DoD Officer & Enlisted	68,686	59,809	14,952	60,594	204,041	1,284,279	15.89%
Military Academy Cadets & Midshipmen	906	1,151	N/A	1,046	3,103	13,056	23.77%
Grand Total (Officers, Enlisted and Cadets/Midshipmen)	69,592	60,960	14,952	61,640	207,144	1,297,335	15.97%

Source: DMDC https://www.dmdc.osd.mil/appj/dwp/dwp_reports.jsp